

WHAT IS CLAIMED IS:

1 1. A process for refreshing a dynamic random access memory, comprising:
2 continuously and dynamically measuring the retention time of all the memory
3 cells of the memory; and
4 regulating the refresh period of the memory based on the result of this
5 measurement.

1 2. The process according to Claim 1, wherein continuously and dynamically
2 measuring the retention time of all the memory cells comprises:
3 successively selecting different groups of cells of the memory in such a way as to
4 scan the entire set of cells of the memory;
5 successively measuring the retention times of each group of cells; and
6 successively refreshing the unselected cells;
7 wherein successively measuring comprises performing measurements on a
8 selected group of cells at a lower measurement frequency than a refresh frequency of the
9 unselected cells of the memory such that each selected group of cells is refreshed more slowly
10 than unselected cells of the memory.

1 3. The process according to Claim 2, wherein the memory is organized by pages,
2 and each selected group of cells comprises an integer number of pages.

1 4. The process according to Claim 2,
2 wherein selectively measuring comprises:
3 writing predetermined test content to the selected group of cells;
4 reading of the selected group of cells; and
5 metering of a number of content errors in the reading of the selected group
6 of cells in comparison to the predetermined test content;
7 wherein selectively measuring the retention time comprises measuring the
8 retention time of all the memory cells by an at least partial accumulation of the metered number
9 of content errors; and
10 wherein successively refreshing comprises refreshing the unselected cells of the
11 memory at least twice in between the writing of the test content to the selected group of cells and
12 the reading of the selected group of cells.

1 5. The process according to Claim 4, wherein successively measuring further
2 comprises, for at least one selected group of cells, backing up of the content of the selected group
3 of cells, and restoring of the content of the selected group of cells with the backed up content
4 following metering of the number of content errors.

1 6. The process according to Claim 4,
2 wherein successive measuring comprises writing of the test content into a first
3 buffer memory before writing to the selected group of cells; and

4 wherein reading of the test content from the selected group of cells comprises
5 writing of the read content of the selected group of cells into a second buffer memory followed
6 by reading of the second buffer memory.

1 7. The process according to Claim 5, wherein backing up comprises storing in a
2 predetermined part of the memory or else in an external backup memory.

1 8. The process according to Claim 6, wherein each selected group of cells forms a
2 single page of the memory, and backing up comprises storing in one of the first and second
3 buffer memories.

1 9. The process according to Claim 4, wherein regulating of the refresh period of the
2 memory comprises:

3 comparing the metered number of accumulated errors with a low threshold and a
4 high threshold;

5 increasing the refresh period if the metered number of accumulated errors is less
6 than the low threshold;

7 decreasing the refresh period if the metered number of accumulated errors is
8 greater than the high threshold; and

9 non-modifying the refresh period if the metered number of accumulated errors is
10 greater than or equal to the low threshold and less than or equal to the high threshold.

1 10. The process according to Claim 4, wherein regulating of the refresh period of the
2 memory comprises:

3 comparing the metered number of accumulated errors with a threshold;
4 increasing the refresh period if the metered number of errors is less than the
5 threshold; and

6 decreasing the refresh period if the metered number of errors is greater than or
7 equal to the threshold.

1 11. The process according to Claim 10, wherein refresh period has a minimum limit
2 value and a maximum limit value.

1 12. The process according to Claim 1, wherein continuously and dynamically
2 measuring the retention time comprises performing retention time measurements for the cells of
3 the memory cyclically, and tagging the cells of the memory having a lower retention time as
4 measured in the course of a measurement cycle, and wherein regulating the refresh period of the
5 memory comprises setting the refresh period in the course of a next measurement cycle of the
6 tagged cells to be refreshed more often than non-tagged cells of the memory.

1 13. The process according to Claim 1, wherein the memory is incorporated into an
2 apparatus which operates in both a standby mode and an active mode of operation, and wherein
3 measuring and regulating are performed at least in the course of the standby mode.

- 1 14. The process according to Claim 13, wherein the apparatus is a handset of a
2 wireless communication system.

1 15. A dynamic random access memory device, comprising:
2 a dynamic random access memory; and
3 a memory refreshing circuit that operates to continuously and dynamically
4 measure the retention time of all the memory cells of the memory, and to regulate the refresh
5 period of the memory based on the result of this measurement.

1 16. The device according to Claim 15, wherein the memory refresh circuit comprises:
2 a selection circuit operating to perform successive selections of different groups
3 of cells of the memory in such a way as to scan the entire set of cells of the memory;
4 a measurement circuit operating to perform successive measurements of the
5 retention times of each selected group of cells; and
6 a refresh circuit operating to perform successively refresh the unselected cells;
7 wherein the measurement circuit is activated to perform measurements on a
8 selected group of cells at a lower measurement frequency than a refresh frequency of the
9 unselected cells of the memory such that selected groups of cells are refreshed more slowly than
10 unselected cells of the memory.

1 17. The device according to Claim 16, wherein the memory is organized by pages,
2 and each selected group of cells comprises an integer number of pages.

1 18. The device according to Claim 16, wherein the measurement circuit comprises:
2 a storage device to store predetermined test content;

3 a write circuit to write the predetermined test content to the selected group of
4 cells;

5 a read circuit to read the selected group of cells;

6 a metering circuit to meter the number of content errors in the reading of the
7 selected group of cells in comparison to the predetermined test content; and

8 an accumulation circuit to perform an at least partial accumulation of the metered
9 number of content errors; and

10 wherein the refresh circuit refreshes the unselected cells of the memory at least
11 twice in between the writing of the test content to the selected group of cells and the reading of
12 the selected group of cells.

1 19. The device according to Claim 18, wherein the measurement circuit further
2 operates, for at least one selected group of cells, to backup the content of the selected group of
3 cells and restore the content of the selected group of cells with the backed up content following
4 metering of the number of content errors.

1 20. The device according to Claim 18, further comprising:
2 a first and a second buffer memory connected to the dynamic random access
3 memory;

4 wherein the write circuit writes the test content into the first buffer memory
5 before writing to the selected group of cells, and wherein the read circuit writes the read content

6 of the selected group of cells into the second buffer memory followed by reading the second
7 buffer memory.

1 21. The device according to Claim 19, wherein the measurement circuit performs the
2 backup in a predetermined part of the memory or else in an external backup memory.

1 22. The device according to Claim 20, wherein each selected group of cells forms a
2 single page of the memory, and backing is made to one of the first and second buffer memories.

1 23. The device according to Claim 18, wherein the memory refreshing circuit
2 comprises:

3 a comparison circuit to compare the metered number of accumulated errors with a
4 low threshold and a high threshold; and

5 a regulating circuit that increases the refresh period if the metered number of
6 errors is less than the low threshold, decreases the refresh period if the metered number of errors
7 is greater than the high threshold, and leaves the refresh period unchanged if the metered number
8 of errors is greater than or equal to the low threshold and less than or equal to the high threshold.

1 24. The device according to Claim 18, wherein the memory refreshing circuit
2 comprises:

3 a comparison circuit to compare the metered number of accumulated errors with a
4 threshold; and

5 a regulating circuit to increase the refresh period if the metered number of errors
6 is less than the threshold and decrease the refresh period if the metered number of errors is
7 greater than or equal to the threshold.

1 25. The device according to Claim 24, further comprising storage means for storing a
2 minimum limit value and a maximum limit value for the refresh period.

1 26. The device according to Claim 15, wherein the memory refreshing circuit
2 cyclically performs the measurement of the retention time of all the cells of the memory, and
3 tags the cells of the memory having a lower retention as measured in the course of a
4 measurement cycle, and regulates the refresh period of the memory by setting the refresh period
5 in the course of a next measurement cycle of the tagged cells to be refreshed more often than
6 non-tagged cells of the memory.

1 27. The device according to claim 15, wherein the device is incorporated into an
2 apparatus which operates in both a standby mode and an active mode of operation, and wherein
3 the memory refreshing circuit operates to measure and regulate during at least the course of the
4 standby mode.

1 28. The device according to Claim 27, wherein the apparatus comprises a handset of a
2 wireless communication system.

- 1 29. The device according to Claim 28, wherein the handset is a cellular mobile
2 telephone.

1 30. A process for dynamically adjusting the refresh rate of a dynamic random access
2 memory array, comprising:

3 selecting a group of memory cells within the memory, the selected group of
4 memory cells comprising a sub-set of the entire memory array;

5 measuring a test data content retention time for the selected group of memory
6 cells at a measurement rate which exceeds a current refresh rate of the dynamic random access
7 memory array;

8 in the meantime, continuing to refresh the non-selected memory cells within the
9 memory at the current refresh rate; and

10 adjusting the current refresh rate based on the measured test data content retention
11 time.

1 31. The process according to Claim 30, further comprising repeating the steps of
2 claim 30 and selecting a different group of memory cells with each repeat so as to scan all of the
3 cells of the memory.

1 32 The process according to Claim 31, wherein adjusting comprises making an
2 adjustment to the current refresh rate based on the measured test data content retention times for
3 all groups of memory cells.

1 33. The process according to Claim 30, wherein the measurement rate is selected in
2 comparison to the current refresh rate so as to refresh the non-selected memory cells at least
3 twice before a test data content retention time measurement is made.

1 34. The process according to Claim 30, wherein measuring comprises:
2 writing test data to the selected group of memory cells;
3 reading the test data from the selected group of memory cells after expiration of a
4 delay set by the measurement rate;
5 counting a number of content errors in the read test data.

1 35. The process according to Claim 34, wherein adjusting comprises:
2 comparing the number of content errors to a threshold;
3 increasing the current refresh rate if the number is less than the threshold; and
4 decreasing the current refresh rate if the number more than the threshold.

1 36. The process according to Claim 34, further comprising repeating the steps of
2 claim 30 and selecting a different group of memory cells with each repeat so as to scan all of the
3 cells of the memory, and wherein counting comprises accumulating the number of content errors
4 with each repeat.

1 37. The process according to Claim 36, wherein adjusting comprises:
2 comparing the accumulated number of content errors to a threshold;

3 increasing the current refresh rate if the accumulated number is less than the
4 threshold; and
5 decreasing the current refresh rate if the accumulated number more than the
6 threshold.

1 38. A process for selectively adjusting refresh rate of a dynamic random access
2 memory array, comprising:

3 successively selecting groups of memory cells within the memory, each selected
4 group of memory cells comprising a sub-set of the entire memory array;

5 measuring a test data content retention time for each selected group of memory
6 cells;

7 in the meantime, continuing to refresh the non-selected memory cells in
8 accordance with their refresh rate;

9 tagging certain ones of the selected groups of cells having a lower test data
10 retention time; and

11 adjusting the refresh rate for the memory cells such that tagged selected groups of
12 memory cells are refreshed more frequently than non-tagged selected groups of memory cells.

1 39. The process according to Claim 38, wherein measuring comprises:

2 writing test data to the selected group of memory cells;

3 reading the test data from the selected group of memory cells after expiration of a
4 delay;

5 counting a number of content errors in the read test data.

1 40. The process according to Claim 39, wherein tagging identifies certain ones of the
2 selected groups of cells whose number of content errors exceeds a threshold.

1 41. The process according to Claim 38, further comprising regulating the refresh rate
2 for non-tagged selected groups of memory cells based on the measured test data content retention
3 times for all selected group of cells.

1 42. The process according to Claim 41, wherein regulating comprises:
2 writing test data to each selected group of memory cells;
3 reading the test data from each selected group of memory cells after expiration of
4 a delay;
5 accumulating a number of content errors in the read test data;
6 comparing the accumulated number of content errors to a threshold;
7 increasing the refresh rate for non-tagged selected groups of memory cells if the
8 accumulated number is less than the threshold; and
9 decreasing the refresh rate for non-tagged selected groups of memory cells if the
10 accumulated number more than the threshold.